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TABLES OF THE HYPERGEOMETRIC DISTRIBUTION FUNCTIONS

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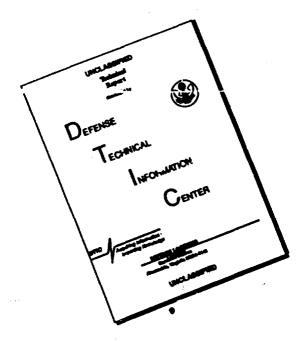
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#### FOREWORD

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Tables and graphs based on the hypergeometric distribution are presented for use in determining the confidence interval of the sample estimate of the number of defectives in a finite population. Similarly, the sample size can be determined which would give a certain quality level as the lower bound for a selected confidence level. The hypergeometric distribution is particularly suited for small populations (less than 1,000) where a saving in the sample size is desired even at the expense of some loss in precision of the estimate.

The tables of point and cumulative probabilities are tabulations of selected sample and population combinations. The selected sample sizes range from 4 to 40 and the population, from 50 to 1,000.

For those that have access to an IBM 1401 Model B-4, 8K memory, the computer program is included as Appendix D.

The authors wish to express their appreciation to A. Ohta and K. Thornton for editing and assembly of the tables and to J. Mitchell for supervising the computer tabulation.

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#### INTRODUCTION

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In quality evaluation, the basic question is: "What is the quality level of the stockpile in question?" More often this question is put in the following form: "How large must the sample be to give a certain level of assurance that the stockpile is no worse than X% defective if no defectives are observed in the sample?" In this latter form, the requirement is not for a precise estimate of the stockpile quality level but rather some assurance that the quality is not below a specified level. In this situation, the implication is that there is some willingness to sacrifice some precision if a reduction in the sample size required can be realized.

Most approaches until recently have been based on the binomial distribution. But in cases where the stockpile is small, say less than 500, and the unit item cost high, the binomial has not been a very satisfactory model. As is normally the case in quality evaluation where the populations are small and sampling is without replacement, it appeared that the hypergeometric distribution was the more realistic model to use, but until the advent of the modern-day computer, the formidable task of calculating the probabilities on a desk calculator prevented its use.

Of primary concern to the Oahu Laboratory is coping with small stockpiles of high unit cost weapons. What is desired is a method whereby stockpiles of extremely high or low quality (percent operability) can be readily detected using a minimal size sample. For stockpiles falling in between, additional samples must be tested if greater precision in the quality estimates is desired. As a result, a study was made of a two-stage sampling method based on the hypergeometric distribution and using 95% operability at the 90% confidence level as the lower bound for "good" stockpiles.

#### APPROACH TO THE PROBLEM

Based on the hypergeometric distribution two main mathematical approaches are proposed.

# Approach I

The first approach may be stated in this mathematical form

(1) 
$$P(D|S, N, M) = \frac{\binom{M}{D}\binom{N-M}{S-D}}{\binom{N}{S}} = \frac{M!}{(M-D)! \ D!} \frac{(N-M)!}{(N-M-S+D)! \ (S-D)!}$$

where: S = Sample size

N = Population sizeD = Sample defectivesM = Population defectives

and obviously

S-D = Sample Non-defectives N-M = Population Non-defectives

Equation (1) states that the probability of obtaining D defectives in a sample of size S, given M defectives in a population of N items, is equal to the number of ways of drawing D out of M items times the number of ways of drawing S-D out of N-M items divided by the number of ways of drawing S out of N items. In stockpile quality estimation it is desired to find the confidence interval for the number of defectives in a finite population. Since M is not known, an upper bound on the true M is sought. Call this bound  $M_U$ . First assume that  $M_U = M_1$ . Then look up in an appropriate table (reference (4)) the sum of the probabilities of drawing D or less defectives in the sample. If this sum is less than eG, the significance level (e.g. . .10), the proper  $M_U$  should be less than  $M_1$ . Then choose  $M_U = M_2$ ,  $M_2 < M_1$  and repeat the above procedure until

$$\sum_{D_i=0}^{D} F(D_i \mid s, N, M_{u}-1) \leq \alpha \leq \sum_{D_i=0}^{D} P(D_i \mid s, N, M_{u})$$

Then select  $M_u$ -1 or  $M_u$  as the upper bound depending on which corresponding sum is closer to C.

The maximum likelihood value is given as  $\stackrel{\wedge}{M} \leq \frac{D}{S} \{N+1\}$ 

(reference 1, p. 294) or more completely  $\frac{D}{S}$  (N+1)  $-1 \le \frac{A}{M} \le \frac{D}{S}$  (N+1)

(reference 3, p. 3). References for this approach are found in (1), (2), and (3).

# Approach II

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The approach followed is to assume that populations with M defectives where M ranges from D to (N-S+D) are tested randomly. In this case  $P(D|S,N,M_1)$  is related to  $P(D|S,N,M_D)$ ,  $P(D|S,N,M_{D+1})$ , ....  $P(D|S,N,M_{N-S+D})$ . The probability of the observed sample coming from a population with  $M_i$  defectives is given as:

(2) 
$$P(M_i \mid D, S, N) = \frac{P(D \mid S, N, M_i)}{N-S+D} \quad \text{where, } D \leq M_i \leq N-S+D$$

$$\sum_{M=D} P(D \mid S, N, M)$$

Equation (2) states that if, from a population of size N, a sample S is drawn and D defectives are observed, the probability of  $M_i$  defectives in the population is equal to the ratio of the probability of that set of  $M_i$ , N, S, and D to the total sets of N,  $M_j$ , S, D where  $M_j$  is allowed to range from D to (N-S+D). The number of defectives in the population cannot be less than the number of defectives observed in the sample nor greater than the difference between the total population N, and (S-D) (sample non-defectives).

The denominator  $\sum_{M_i = D}^{N-S+D} P(D|S, N, M_j)$  can be shown equal to  $\frac{N+1}{S+1}$ ,

a constant. This makes it valid to tabulate P(D S, N, M) instead of P(M S, N, D) for checking purposes. In the form of equation (1), equation (2) becomes the derived equation:

(3) 
$$P(M \mid D, S, N) = \frac{\binom{M}{D} \binom{N-M}{S-D}}{\binom{N+1}{S+1}} = \frac{S+1}{N+1} P(D \mid S, N, M)$$

For brevity, let  $P(M_i \mid D, S, N) = P(M)$ . Then these recurrence relationships are very useful for computational purposes:

(4) 
$$\frac{P(M)}{P(M+1)} = \frac{(M-D+1) (N-M)}{(M+1) (N-M-S+D)}$$

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(5) 
$$\frac{P(M)}{P(M-1)} = \frac{(M) (N-M-S+D+1)}{(M-D) (N-M+1)}$$

From (4) and (5) it can be seen that P(M) > P(M+1), where they exist, as long as (M-D+1) (N-M) > (M+1) (N-M-S+D) and similarly P(M) > P(M-1) as long as (M) (N-M-S+D+1) > (M-D) (N-M+1). It follows

that the maximum likelihood integer M may be expressed as:

(6) 
$$\frac{D}{S}$$
 (N+1)  $-1 \le M \le \frac{D}{S}$  (N+1)

There will be two M values where the extreme right and left expressions are: (a) integers and (b) exist. Since equations (4), (5) and (6) show that the probabilities decrease from the maximum likelihood value, serial computations should start with M as shown below in equations (72) and (7b). (Note: M differs from that in [Reference 1] and [Reference 3].)

(7a) 
$$P(M) \ge P(M-1) \ge P(M-2) \ge \dots P(M-k)$$

(7b) 
$$P(M) \ge P(M+1) \ge P(M+2) \ge \dots P(M+i)$$

(7c) 
$$\sum_{\mathbf{R}}^{\mathbf{T}} \mathbf{P}(\mathbf{M}_j) = 1 - \infty$$

If  $P(M+i) \ge P(M-k)$ , P(M+i) is added to  $\sum P(M_j)$  which starts with P(M); otherwise P(M-k) is added. Equation (7c) states that R to T

is the range of M defectives in the population when the sum of all the higher probabilities is equal to  $1-\alpha_4$  the confidence level.

(8) 
$$\sum_{D}^{L} P(M_j) = 1-\infty$$
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L being determined by computations. Equation (8) gives the upper bound of  $M_j$  or the so-called one-tail test for small values of D. For D = 0 and D = S, the one-tail and two-tail tests coincide. For most values of D, the probabilities form an asymmetric as well as a discrete distribution. The asymmetries are illustrated in figure 1 where curved lines are drawn through point probabilities for N = 50, S = 8, and D = 0 to 4.

Approaches I and II may perhaps be better illustrated by the use of black and white missiles.

There are six missiles in the population - four white and two black. The three possible outcomes in a sample of three are labeled (a), (b), and (c); the chance or probability of drawing any one is determined by equation (1).

Approach II. In stockpile quality evaluation it is desirable to take approach II which is the more realistic statistical model. In this case the population is estimated from a known sample.

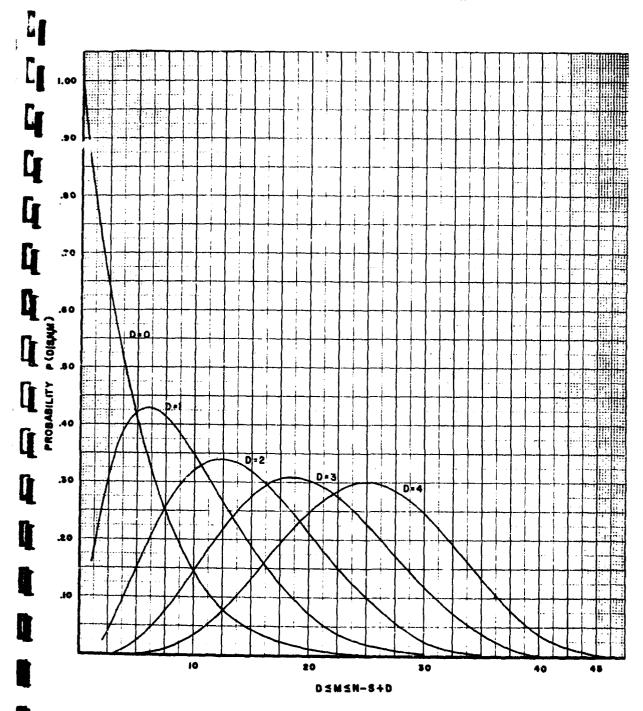


FIGURE 1. CHANGE IN SHAPE OF GENERALIZED POINT PROBABILITY CURVES DUE TO THE NUMBER OF DEFECTIVES PRESENT IN A SAMPLE.

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Here, from a population of six, is a sample of three wherein two white and one black missiles were noted. The four possible populations from which this sample could have been drawn are: (d), (e), (f), and (g). The chances or probability of any one of the populations being the one from which this particular sample is drawn is determined by equation (3).

### Symmetries

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Since  $\frac{S+1}{N+1}$  P(D|S,N,M) = P(M|S,N,D) by equation (3), symmetries given by Lieberman and Owen (Reference 4) for P(D|S,N,M) apply in many instances where S and N are fixed.

(9) 
$$P(M = M_1 | D_1, s, N) = P(M = N - M_1 | s, s - D_1, N)$$

(10) 
$$\sum_{M=A}^{B}$$
  $P(M|S,D=D_1, N) = \sum_{M=N-A}^{N-B}$   $P(M|S,D=S-D_1, N)$ 

Equations (9) and (10) show that tables need only involve half the sample size.

Population defectives M given and sample size S unknown

(11) 
$$P(M|D,S,N) = P(S|D,M,N)$$

(12) 
$$\sum_{S=D}^{N-M+D} P(S|D, M, N) = \frac{N+1}{M+1}$$

Equations (11) and (12) give the basic equations for the problem of sample size estimation when N, D, and M are known. Any table for M defectives may be used by interchanging S for M.

#### Two Stage Sampling

Out of a total allowable sample of size S from a population N, an initial sample  $S_1$  is tested and  $D_1$  defectives are found. By means of a

table similar to Appendix C, it is found that x defectives gives the desired percent operability and y defectives (y > x) do not. If  $D_1 \le x$  then the lot is accepted. If  $D_1 \ge y$ , the lot is rejected. If  $x < D_1 < y$ , then the remainder of S, called  $S_2$ , is sequentially tested. If at any time a total of  $D_1 + C$  defectives are found, the lot is rejected, since the total sample S would have at least  $D_1 + C$  defectives. If the total sample S is tested and  $(D_1 + C - 1)$  defectives are found, the lot is accepted.  $D_1 + C$  is determined from the probability table for N, S, and M, the number of defectives that will be tolerated.

#### Best Sample Size S for a Given D

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For some values of D sample defectives, a large sample size S is required to reach the desired percent operability for a given confidence level. In these cases, the percent operability should perhaps be lowered to the point where the additional sample units give less than some preselected gain value in percent operability. This is illustrated in figure 2, which is patterned after the graphs in Appendix B.

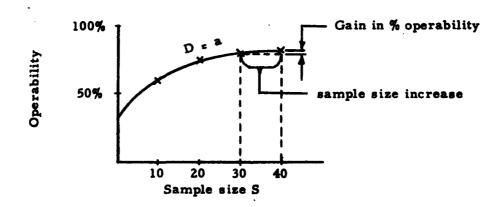


FIGURE 2. SAMPLE SIZE VERSUS OPERABILITY.

Here for D = a, an additional sample of 10, from 30 to 40 will result in a very small gain in percent operability and therefore, S = 30 may be the better choice of sample size.

#### RESULTS

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#### Tables and Graphs

The table and graphs in Appendices A and B are useful as "quick look" references. The table gives the range for population defectives for certain fixed confidence levels. The graphs give different population lines in terms of percent operability versus fixed sample sizes. Smooth curves are drawn through interpolated points. Only the lower percent operability values are plotted for clarity.

## Print-out of Probabilities

A sample of the computer print-out of probabilities is given in Appendix C. Point probabilities and sums for P(D|S,N,M) were tabulated instead of P(M|D,S,N) for purposes of checking with other tables.

#### The abbreviations are:

S = Sample size

N = Population size

D = Sample defective

M = Population defective

P = P(D|S, N, M)

 $SUM = \sum_{M=R}^{T} P(D|S, N, M)$ 

where the sum contains the highest probabilities from R to T

$$M = R$$

$$T$$

$$CONF = \sum_{R} P(D|S, N, M)$$

$$R$$

$$N - S + D$$

$$D$$

$$P(D|S, N, M)$$

$$M = D$$

LEFT SUM = Sum of decreasing probabilities to the left of maximum likelihood

RIGHT SUM \* Sum of decreasing probabilities to the right of maximum likelihood

A one-tail test is possible from this type of table. Assume 1-62 is the confidence level,  $Q = \sum_{M=D}^{N-S+D} P(D[S, M])$ , and

 $R = \sum_{M=M+1}^{N-S+D} P(D|S, N, M).$ 

Compute OCQ and subtract from R. Then trace back in the "Right sum" column until a value just exceeding R - OCQ is found. The value of upper M in the same row is the one-tail upper bound on the population defectives.

# Program for the Hypergeometric Series

The symbolic language program developed for the IBM 1401 computer, Mod B4, is given in Appendix D. Accuracy in computation of factorials was mainly accomplished by having the decision to multiply by a number from the numerator or divide by a number from the denominator depend upon the number of leading zeros resulting from the previous calculation. Individual probabilities were then usually accurate to ten places and sums of probabilities to eight.

The abbreviations used in the print-out in Appendix D are:

PG LIN \* Page and line identification

CT = Count for instruction or reserved storage

OP = Operation instruction

A OPERAND - A or I address of instruction

B OPERAND = B address of instruction

D = D character modification of the basic instruction

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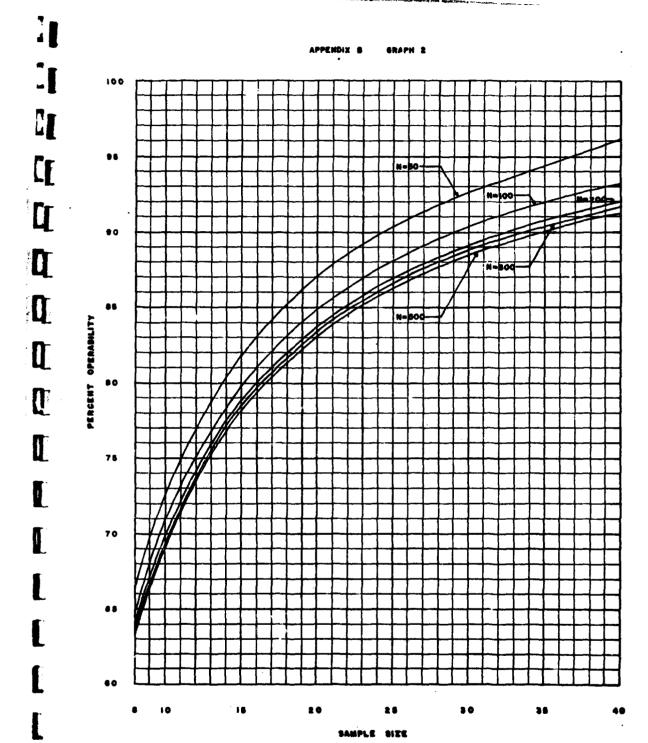
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*	25	1 2 3	0 2 3 17 28	38 96 70 98	0 1 6 14 23	65 55 56 56 56 56 56 56 56 56 56 56 56 5	***	10	1 2 3	6 29 66 96	93 157 214 270 318	8 4 21 46	118 103 340 293 339	700	25	1 2 3	9 3 14 20 47	90 90 137 174 301	0 2 10 23 39	74 118 197 194 889
	*	1 2 3	0 2 7 15 25	27 47 45 83 100	1 4 12 19	35 94 78 93		12	1 2 3	6 5 23 46 77	35 184 233 274	9 3 17 30 64	101 198 209 255 297		30	1 2 3	9 3 12 25 37	67 84 116 167 176	.2 9 19 32	63 180 133 164 196
	35	1 2 3	12 20	83 86 71 86	1 5 10 16	***		15	1 2 3 4	4 13 37	44 111 154 173 231	0 2 13 30 30	84 131 174 214 251		35	1 2 3 4	2 10 21 33	41 71 100 127 152	1 7 17 27	64 65 115 143 146
	•	3 4	1 3 11 17	26 47 43 75	1	16 48 97 71 64		17	3 4	3 16 32 52	99 99 139 174 206	11 24 43	75 110 154 193 224		•	2 3	18 29	37 63 66 111 134	1 7 15 24	47 75 102 134 149
-	•		7 36 70 116	100 100 234 206 236	4 25 97 74	136 198 254 307 363		**	3	13 27 43	90 94 119 131 100	2 10 22 36	65 102 137 168 190		10	•	16 75 156 253	225 275 314 438 746	9 96 125 213	262 452 544 404 797
	10	3 4	# # #	86 141 196 249 286	3 19 43 73	104 144 214 263 305		 **	3 4	2 10 21 34	41 70 97 123 147	1 1 17 18	53 83 112 136 142		12	3 4	12 97 110 191	186 315 433 640 630	91 91 140	297 3 y 6 462 506 601
	15	***	4 21 45 70	72 121 160 201 201	3 15 25 28	94 142 167 230 246		36	1 2 3 4	1 7 10 26	34 39 82 194 125	1 6 14 23	46 70 94 117 130		15	1 2 2 4	10 46 45 153	161 271 374 468 555	9 33 75 127	304 317 417 513 597
	17	•	**************************************	39 100 130 175 206	12 12 27	76 110 157 193 224		•	3 4	; ; ; ;	29 51 71 90 100	1 6 12 20	34 60 82 301 120		17	3,	7 35 74 118	234 318 390 463	25 39 78	167 264 390 430 503
		1 2 3	3 14 29 47	83 89 136 156 167	2 10 23 39	67 106 141 173 204	_		3 4	2 7 13 21	24 45 63 79 98	\$ 11 17	35 53 72 90 185			3	6 31 64 103	201 279 350 417	9 4 32 90 95	198 230 316 307 -486
	•		3 12 25 39	76 106 136 142	; ;	\$6 98 123 151 177		10	3 4	11 52 107 177	197 362 369 446 523	4 37 48 147	396 478 480			1 2 3	16 16 16 16	102 173 341 304 363	3 10 42 70	131 204 274 238 297
	**		19 19 31	37 43 67 110 133	) 7 15 25	47 74 100 123 146		12	3 4	65 134	219 203 270 404	3 29 66 112	148 254 237 418 674		<b>M</b>	1	42 67	83 148 197 348 297	2 14 31 56	107 146 825 876 386
		1	16. 28	31 53 76 95 113	1 6 13 21	40 43 95 100 134		15	3 4	9 7 34 67 100	109 261 267 266	4 23 55 70	141 222 293 396 410		<b></b>	3	4 17 33 14	76 130 107 311 252	12 12 87	90 143 191 234 276
			; ; ; ;	24 44 44 41 77	1 5 11 10	36 56 73 91 107			3 4	# # # # #	92 156 2)7 272 204	3 18 61 67	110 104 346 300 362			1 2 3 4	3 14 29 47	40 200 344 388 818	10 20 20 30	70 155 150 150 150 150 150 150 150 150 15
	~		1 1 18 19	25 39 36 71 66	1000	**			3 4	# <b>6</b> 77	63 141 190 204 201 71	3 16 36 66	106 166 221 271 310		**	1 2 3	3 12 24 61	\$3 \$1 184 184 198	***************************************	\$7 100 HE
	_	•	10 10 197	107 207 310 314	45 43 107	140 216 201 261 293			i 2 3	11 22	71 181 160 212 263	11 13 20	94 143 194 194 194							

SAMPLE SIZE

PERCENT OPERABILITY VERSUS FIXED SAMPLE SIZE .SO CONFIDENCE LEVEL FOR NO DEPERTWE



PERCENT OPERABILITY VERSUS FIXED SAMPLE SIZE .00 COMPIDENCE LEVEL FOR ONE SEPECTIVE

q

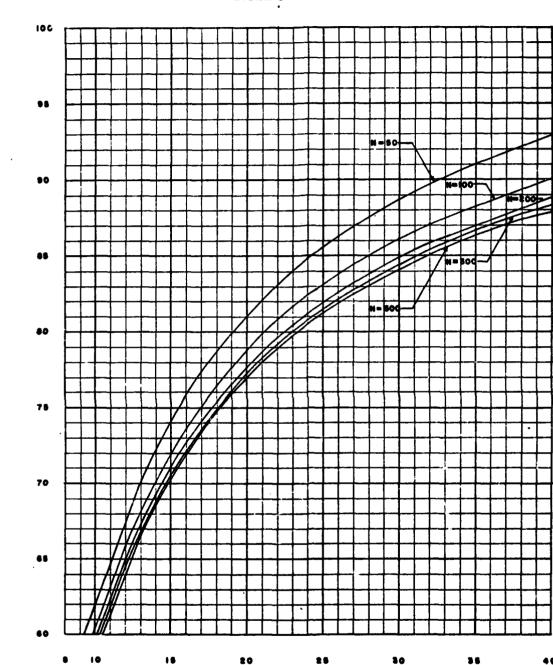
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PERGENT OPERABILITY VERBUS FIXED SAMPLE SIZE .90 CONFIDENCE LEVEL FOR TWO DEFECTIVES

U

Q

					HYPERGE	OMETRIC S	EE 152					
5	*	٠	N	•	SUN	COMP		1mt#	RVAL		LEFT SUM	ASSMT SUM
•	50	•	•	0.99999999	0.00000000	0.0780		4 4444				0.91999999
:	50 50 54 54 50 50	:	ž	0.919999999 0.0449979991	1.9199999999 2.7646979591	0.2710	:	0.0000 0.0000 0.0000	į	0.0200 0.0400	0.000000000 0.000000000	1.764897939
ě	50	ĕ	š	0.7744897959	3.5393877550	0.3449	0	0.0000	3	0.0400	0.000000000	2.539307755
•	50	•	•	0.7965757767 0.6467664863	4.2479435258	0.4144	8	0.0000	•	0.0800 0.100¢	0.000000000	3.2479639236
7	22	:	:	0.5894528875	5.4843748994	0.5376	ĭ	0.0000	- 1	0.1200	0.000000000	4.484374899
Ä	90	ě	ī	0.5350642613	6.0202431610	0.5982	ŏ	0.0000	Ť	0.1400	0.000000000	5.0202431610
:	50 50	•	•	9.4 <b>940</b> 182370 9.4397307 <b>9</b> 59	6.5062613781 6.9459721841	0.6378 0.6 <b>007</b>	•	8.0000 8.000ú	÷	0.1400 0.1800	0.000000000	5.906261998 5.945992184
•	50		10	0.3940302214	- 3428224055	0.7196	•	eeod.a	10	0.2000	0.000000000	6.742022405
•	-	•	11	0.3571471993	7.6777676048 6.0204863221	0.7548	•	0.0000	11	0.2200	0.000000000	6.6777676040 7.020486322
•	50 50	:	13	0.3205167173 0.2867781155	8.3072644376	0.7843 0.8144	8	0.0000	12	0.2400 0.2600	0.000000000	7.307244437
i	50	ŏ	14	0.2557750759	0.5430395136	0.8393	ŏ	0.0000	14	0.2900	0.000000000	7.5630395130
•	50 50	•	15	0.2273556231	8.7903951367	0.0618		0.0000	15	0.3000	0.000000000	7.790395136
•	50 50	:	14	0.2013721233 0.1774812852	9.9917672600 9.1694483453	0.0815	0	0.0000 0.0000	16	0.3200	0.000000000	7.991767268
	50	ŏ	10	0.1541441597	9.3255927051	0.9142	ĕ	0.0000	iė	0.3600	0.000000000	8.325592705
٠	50	•	19	0.1364261390	9.4422198449	0.9274	•	0.0000	34	0.3000	0.000000000	8.462218944
:	50 50	0	20 21	0.11 <b>89969604</b> 0.1031304 <del>99</del> 0	7.5812150054 7.6843465045	0.7393 0.9494	0	0.0000	50	0.4000 0.4200	0.000000000 0.000000000	8.501215005 8.664346504
4	50	ě	55	0.0889057750	9.7732522794	0.9581	ŏ	0.0000	22	0.4400	0.000000000	0.773292279
4	50	•	53	0.0762049500	9.8494572296	0.9656	0	0.0000	53	0.4400	0.000000000	R.849457229
:	50 50	0	24 25	0.0649153278 0.0549283543	9.914372557 <b>5</b> 9. <b>9693009</b> 118	0.9719	0	0.0000	24 25	0.4000	9.000000000	0.914372557 0.969300911
-	90	ŏ	26	0.0461396176	10.0154407294	0.7017	ŏ	. 0.0000	26	0.5200	0.000000000	9.015440729
•	50	ā	27	0.0384498480	10.0538905775	0.7854	ō	0.0000	27	0.5400	0.000000000	1.053010577
•	50 58	0	28 29	0.0317629179 0.0259878419	10.0054534954	0.9987 0.9913	0	0-0000	28 29	0.5600 0.5800	0.000000000	9.005653499 9.111641337
•	50	0	30	0.0210377766	10.1324791141	0.9933	•	0.0000	30	0.4000	0.000000000	9.132679114
4	50	•	31	0.0168302214	10.1495093356	0.9990		0.0000	31	9.4200	0.000000000	9.149509335
*	50 50	8	32	0.0132870147	10.1627963525	0.9943		0-0000	33	0.4400 0.4400	0.000000000 9.000000000	9.162796352
:	50	ĕ	34	0.0079027355	10.1810334346	0.7773	ä	0.0000	34	0.4800	0.0000000000	9.181033434
Ä	50 50	ō	34 35	0.0059270516	10.1847464843	0.9767	ō	0.0000	35	0.7000	0.000000000	7.186760484
•	30	0	34 37	0.0043445045	10.1913009906	0.7771	•	0.0000	36	0.7200	0.000000000	7-191304990
:	50 50	÷	37 30	0.0031046461 0.0021493703	10.1944116369	0.9794	÷	0.0000	37 38	0.7400 0.7 <b>40</b> 0	0.000000000	9.194411636
Ä	50	ě	ñ	0.0014329135	10.1979999209	0.7798	ě	0.0000	37	0.7800	0.000000000	9.197993920
4	50	0	40	0.0009118541	10.1989057750	0.9990	•	0.0000	40	0.8000	0.000000000	9.198905775
•	50	0	41	0.0005471124 0.0003039513	10.1994528875 10.1997548388	0.9999	ě	0.0000	42	0.8200 0.8400	0.000000000	9.1794524879 9.179754638
7	50 50	ě	43	0.0001519756	10.1999000145	0.7777	š	0.0000	75	0.8400	9.000000000	7.199908014
Á	50	ō	44	0.0000651324	10.1999739470	0.9999	0	0.0000	44	0.8000 0.9000	6.000000000	9.1999739470
•	50 50	0	45	0.0000217100	10.199995657# [G.[ <del>9099999</del>	0.9999 8.9999	0	0-0000	45	0.9000 9.9200	0.000000000	9.199996576 9.19999999
4	50	ĭ	12	0.4395657837	0.4395457837	0.0430	•	******	**	0.7200		***********
:	50 50 50	i	13	0.4344018237	0.8781474074	0.0430	12	0-2400 0-2200	13	0.2400 0.2400	0.000000000 0.4365132435	0.4386018237
	50	1	14	0.4340425531	1.7487234042	0.1714	11	0.2200	14	0.2000	0.4345132435	0.87244376
4	50	1	10	0.4290050448	2.1777290490	0.2135	10	0.2000	14	0.2000	0.8655188884	0.8726443766
٠	50	1	15	0.4262917933	2.4040208423	0.2552	10	0.2000	15	0.3000	0-8655188884	L.290934170
:	50 50	- }	16	0.4165 <b>87666</b> 3 0.415 <b>735996</b> 5	3.0204079027 3.4365438992	0.3348	•	0-1800 0-1800	15	0.3000	1-2021039407	1.278736178
4	50	i	17	0.4027442466	3.8390001436	0.3743	ij	0.1800	17	9. 3400	1.2021059487	2.117416413
٠	50	1		0.3987841945	4.2378723404	0.4154	•	0-1400	17	0.3400	1.4000901432	2.117416413
•	50 50	,	18	0.3876682567 0.3751063629	4.4235405792 5.0004467621	0.4534	÷	0-1400	18	0.3400 0.3400	1-4400901432	2.505094472 2.505004472
ï	50	i	Ļģ	0.3700423745	5.3714893616	0.49 <b>02</b> 0.5244	÷	0.1400 0.1406	10	0.3000	2.0559965262 2.0559965262	2.075927051
٠	30	1	20	0.3525835864	5.7240729483	0.5611	7	0-1400	20	0.4000	2.0599965262	3.220310430
•	50			0.3450455927	4-0491185410	0.5990	•	0-1200	20	0.4000	2-4010421107	3.220510030
-	50 50	i	21 22	0.3331914 <b>0</b> 93 0.31 <b>29</b> 463 <b>26</b> 2	4.4023100303 4.7152503586	0.4276 0.45 <b>0</b> 3	:	0.1200 0.1200	55 51	0.42 <b>00</b> 0.44 <b>00</b>	2.4010421109 2.4010421109	3.561762127
ě	50 50	Ĭ	5	0.3680764228	7.0233347007	0.4485	š	0.1000	22	0.4400	2.7091185410	3.874450459
٠	50	1	23	0.2921189752	7.3154537559	0.7172	3	0.1000	53	0.4400	2-707[1854]0	4-166769431
:	50 50	i	24	0.2707509335 0.2636561007	7.5064046095 7.8500407902	0.7437 0.74 <b>7</b> 6	•	0.1000	24	0.4000	2.70911 <b>05</b> 410 2.9727744417	4.437720364
ě	58		25	0.2496743378	8.0997351200	0.7940	•	0.1000 0.0000 0.0000	25	9.4000 9.5000	2.9727744417	4.437720344
•	50	1	26	0.2209019999	0.3282370626	0.8164	4	0.0000	24	0.5200	2-9727746417	4.713076454
•	50 50	1	27	0.2112244 <b>0</b> 07 0.2076201793	0.5394615718 8.747 <del>09</del> 07511	0.6572 0.6575	3	0.0406	26 27	0.5200 0.5400	3.1830991313 3.1830991315	4.713070654
٠	50	i	20	0.1872340425	8.9343247937	0.8759	ž	0.0400 0.0400 0.0400	20	0.5600 0.5800	3-1639991315	5.310799070 5.478237002
:	50 14		29	0.1474773034	9.1010019973	0.0023	2	0.0000	29	0.5000	3-1039991313	
-	50	i	30	6.1 <b>562040</b> 014 8.14 <b>050</b> 1957	7.2520040776 7.4605000327	0.9214	2	0.0400	29	9.3000	3.3342032131 1.3342032131	5.476237062
ě	22	į	31	0.1304342162	1.5364455495	0.9344	i	0.0400	ñ	0.6200	3.3342032131	5.757173258
:	50	1	32	0.1133025445	9.6449247937	0.9455 0.9550	į	0.0100	35	0.4440	3.3342032131	5.870999700
:	94 94	ì	33	0.0074301241 0.0026747720	9.7417629179 9. <b>82</b> 443 <b>76897</b>	0.9631	3	0.0400 0.0400 0.0400	33	0.4400 0.4000	3.3342632131 3.3342632131	5.967993920 6.07046613
٠	50	1		4.07000000	9.9044376099	0.9710	1	0.0200	34		3.4142032131	4.070440403
:	30	•	33	0.0071407341	0.0716664741	0.9778		0.0200	35	0.6000 0.7000	3.414 <b>20</b> 32131	4-119017629
:	77	- 1	34 37	0.0300776700 0.0460407404	19.9704963221	0.9633 0.9670	;	0.0200	34	0.7200 0.7400	3-4142032131 3-4142032131	4.176717325
•	50	i	30	0.0340745760 0.0457407424 0.0345004776	10.0304043221 10.0744330044 10.1127395422	0.9914	i	0.0200	34	6.7000	3.4143332131	0.22200007 0.22200007
•	30	ì	34 39	0.0279412198	10.1406773773	0.9941	ī	0.0200	34	0.7000	1.4143653111	4.204400300
:	2	1	40	0.0200423793 0.0149944072	10.1619197966	0.7762		0.0200	40	0.0200	3.4142032131 3.4142032131	6.20000000 6.307790790 6.322705367
•	30 30 30 30 30 30 30	i	3	0.010212700	10.1704741041	0.9974	1	6.6204	41	0.0400	3-4/45635131	0-332705307
ė	30	i	43	0.0005347344	10.193221044		i	0.0200	43	0.0000	1.4142022131	6-339452007

er 100 ca 1401 - a.	A STRAIGHT A STRAIGHT A	PE LIN ET LANGE OF	A 0000000	
	Add Streets Streets	Fig. 1.10   C.   Lank.   Fig.	•	T.
1	Sing from from flots of has line twent Singl Guittin 9 70 to to procent count introduction that South	023		-
110 1 100	initial fine series	100 × 100 × 100	,	
1 130 2 AND SC 1 250 10 AMBRO SC 1 240 1 A SC	•	TO SAME		•
1 100 2 0100 DE	•	1 100 1 40001 100	<b>:</b>	
1 200 I Marine of	:		•	
	•	1 100 11 10000 100		
1   10   2   10   10   10   10   10	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	6 176 31 0000 000 6 190 31 00000 000 6 190 31 0000 000 6 200 31 0000 000 7 000 6 0.0000 000 7 000 6 0.0000 000	u u	<b></b>
1 100 L 100 E		T ON S SHOWE SCE		₩.
		7 000 6 Manus SCI	ũ	THE REAL PROPERTY.
	1		`	=
1 040 1 Min 05	; ; ; ;			=
2 576 SEEDON DE				L PAN
2 000 10 DOMES DE 2 100 4 DOMES DE 2 110 0 DOMES DE	0001	A ODG I ADGRAF DE	'	
7 170 32 EMPRAL 651 2 190 32 BOTTAN 651	•	OF LAST K	. :	
1 100 1 100 E	:			_
2 370 5 66702 6C1 2 190 30 MGCH 6C1 2 200 1 661607 6C	•		SUR SUF SUTTONIAL	á
2 210 1 PLOST DC		0 200 00 00 0 200 00 00 0 100 00 00 0 100 10 00 0 100 11 HEADE 00	LEFT SUR BUT	
		170 1 00071 NC	9901 9901	15
3 090 30 HBL090 BC	:		0001 0001 0007 0007 0007 0007 0002 0007 1 TyTu 0270	
3 000 30 HBLBE 0C	•		LEFF FUN A  OFFICE OFFI  OFFI	
1 120 1 L000 0C	•	anemat Sc	LCAMO &	
3 146 26 11763 BCI 3 156 26 12766 BCI 3 186 26 12705 BCI	•	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 0000 \$200 6520	
3 170 30 LEVENS OC	:		1 4014 4014 1 4010 101 1 4014 1014	
3 300 20 LEWIS OC	3UR P		257297 AS	
3 230 26 660725 OCI 3 240 6 64007	n sun	100 Carpes (M	1 A6601 775725 E	
3 350 20 L00710 0CI 3 340 2 LPS 0CI 4 414 5 L0101 ACI	** **		000   101	
4 030 # LEGRA DE	CONTINUE TEXT DIGGO		#956 TUSTES #6 TUSTES #6 TUSTES	
MASS SE	•		1000 TESTAL 1001 TORTON	
1 010 # BANK! BE	•	1 2 3 Common E	10 15 MLT +000	
	•			
			## 1	
			017 -007 MM2	_
	. 1016 115 115			٠.,
	•		Ann Will	
	•	10   10   10   10   10   10   10   10		
1 000 21 7404 56 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	:			١.
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			11 11 11	
	;	1 2 2 2 2		

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	PG 430 CT	LARGEL B	P 4 005 44HG	0 0000000	0	PE 438 CT	LAGEL	*	A OFERAM	1 011440	•
17   246   7   Camp	_			DIV +010		19 130 3	A1004 ED	**	Canon A		
7   240    7   Camp   24   Addition   Tables   70   7   7   7   7   7   7   7   7	12 000 3	4	A 66 963/1	MAT +804				PĒ ŽĀ	···	185724	
17   246   7   Camp	12 000 7		En 917 +919	esus				5 6 M	9C tr1	186126 165726	
17   246   7   Camp	12 000		A COMOO REUM	MAT 4055	ı			1 h	2	•	
17   246   7   Camp	12 130	i	A COMPS	MALT +001				EA ZA	25.00	į.	
17   246   7   Camp			CH MALT +820	LEVES		19 616 7		EA EZ	MASI -001	MARGE MARGE	
17   246   7   Camp	12 150		REGIO			10 030	MALTPA	Î.A	COMPRI MARST	125724	
17   246   7   Camp	1 1 100		A COMPS	MALT +001		10 000		ens	INAME ION OCAS	785728 785728	4
17   246   7   Camp	15 65		CH MLT +620	LEVOS		19 970 7		MCM	MARGT +025	MALT HOLY	
17   246   7   Camp			L BOAT 4424	MALT +B22		19 100		6	BENT	MAGT +614	
17   246   7   Camp	11 656		IOP COMERS	MULT +002		19 110 6		BWE	CHESES INT LAU	MONEY	•
17   246   7   Camp	13 070	i ii	## ##LT +424 ### ################################	MT1 +005 FEACHT		10 100	MULTING	E#	101014 101014	PHILIPPINE.	•
17   246   7   Camp	13 000		180 45141 180 180.7 +020	MULT +623		10 100	MANNE NO	14	MARS3	MARST	
17   246   7   Camp	13 110	COMMIN E	CONTEL.			19 100		14	2240	MAGE	
17   246   7   Camp	14 626		A ES	•		10 100		<u>.                                    </u>	MARK!	186720	
17   246   7   Camp	14 840 1	, ,	14 M016	έ		2000		346	Finish	PONLY	ī
17   246   7   Camp	14 644 1 24 676	;	MAT MS	ŧ			-		<b>EARTH</b>	ents.	
17   246   7   Camp	14 900		A MS.	•	_	IEE :		MCM	MA.7 +914	PRODUCT PRODU	
17   246   7   Camp	14 100		INT WEND!	•	i	122		MCW EA	MAT +019	PROOFI 313923	
17   246   7   Camp	14 120 24 130		HE WEND!	<u>.</u>	ì		}	ŽĀ	22 AC	SUMPL	
17   246   7   Camp	14 140		•	5			;	E CA	180721-005 SUMP21-005	0237 0237	
17   246   7   Camp	10 100			=			;	LCA	LEGT21-005 SUNF21-005	0255 0255	
17   246   7   Camp	10 100			MAG1		2 100	;	HCS HCS	MD 26	6264 6264	
17   246   7   Camp	35 910			NAME ?		2 12		SCA.	PČ1 -005 0101		
17   246   7   Camp	25 000		a A	MARKS MARKS		21 010	;	HCE LCA	#047 PCT -005	021 <del>0</del> 021 4	
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#### U. S. NAVAL AMMUNITION DEPOT OAHU. HAWAII

1804:sm 5220/NT 3 Jan 1963

From:

Commanding Officer

To:

Chief, Bureau of Naval Weapons (FQ-1)

Department of the Navy Washington 25, D.C.

Subj:

Tables of the Hypergeometric Distribution Functions

Encl:

- (1) Mathematical derivation of the tables
- (2) Tables of point and cumulative probabilities for various sample and population size combinations
- 1. Enclosures (1) and (2) are forwarded for publication by the U. S. Government Printing Office. Enclosure (1) contains mathematical derivation of the hypergeometric distribution function, tables, graphs and IBM 1401 computer program. Enclosure (2) (forwarded under separate cover) contains two copies of the tabulations of the hypergeometric probabilities.
- 2. The tables, which include point and cumulative probabilities are designed primarily for use by personnel familiar with statistics to estimate stockpile quality level.
- 3. Copy addressees are advised that copies of the tabular presentation, enclosure (2), which are quite voluminous cannot be made available by this command. It is presumed that they will be generally available through the Bureau of Naval Weapons or the Government Printing Office if the Bureau of Naval Weapons decides to have them published.

H. H. MEEKER, JR.

By direction

Copy to:

Distribution list (w/o encl (2))